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THE ABSOLUTE RADIANT INTENSITY OF THE CENTER OF THE SOLAR DISC IN THE SPECTRAL RANGE 6389 ≤ OR = LAMBDA ≤ OR = 12480 A

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Environmental Protection Agency
Research Triangle Park, North Carolina

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THE ABSOLUTE RADIANT INTENSITY OF THE CENTER OF THE SOLAR DISC IN THE SPECTRAL RANGE $6389 \leq \lambda \leq 12480$ Å

D. Labs and H. Neckel

Absolute intensities for the center of the solar disc are given in the spectral range from 6389 to 12480 Å. The observations are made in exactly the same manner as described in Z. Astrophys. 55:269(1962) for the visible part of the spectrum.

The infrared intensities are measured only in those spectral regions which are practically free from atmospheric absorption bands. The results are given in a table.

This work reports the absolute radiant intensities of the center of the sun in the near infrared spectral region.

The experimental arrangement and the method of measurement were described in detail earlier by D. Labs and H. Neckel (1962) [cited in the following as (LNI)]. For the infrared spectral region we merely exchanged the grating of the double monochromator for one with a blaze wavelength of 7,500 Å and used a 12-stage dry-ice-cooled infrared multiplier from Lallemand as the radiation receiver. All the work was done in the first order of the grating. Higher orders could be removed by properly selected colored glass filters (cut-on filters: Schott GG 14-2 mm or RG 5-4 mm).

The number of solar Fraunhofer lines is already very small above 6,000 Å. Only isolated strong lines occur. Spectrophotometry with reasonably narrow spectral bandwidth covers the true continuum here without difficulty. As one can assume that the curve of the continuum is smooth, it is no longer necessary to cover the entire spectral range (6389 - 12480 Å) without gaps, as we did in the visible region, for instance (LNI). In

practice this is not even possible, because a considerable part of the infrared spectrum is distorted by atmospheric absorption bands and inaccessible for measurements from the ground [1].

We have measured the solar intensity at a total of 31 wavelengths in the spectral range 6389 $\leq \lambda \leq$ 12480 Å (see Table). The atmospheric extinction was determined at 7 wavelengths (LNI, page 279).

Below 6,800 Å the monochromator wavelengths could be adjusted precisely by observing the exit slit (LNI). There is no such possibility between 6,800 and 8,000 Å, unfortunately. There was nothing to be done but to rely on the calibration of the λ drum of the monochromator. This calibration was checked continuously with a line radiator (low pressure spectral lamp). Above 8,000 Å one can again make the adjustments visually, using the second-order spectrum.

It was possible to perform measurements on a total of 10 days of September/October 1962. The site of the observations was (as in LNI) the Sphinx platform of the High Alpine Research Station at Jungfraujoch, Switzerland.

Figure 1 shows the reflectivity of our collimating mirror (see LNI, page 276, for the measuring method). In the upper part of the figure we have plotted the percentage deviation of the individual series of measurements from the mean (point in the log $1/R(\lambda)$ presentation).[2] The wavelengths of our solar

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(1) It is practically impossible to determine the extinction of these bands accurately enough with the usual means.

(2) In averaging, the individual measurements were weighted differently, so that the sum of the deviations in the figure is not zero.

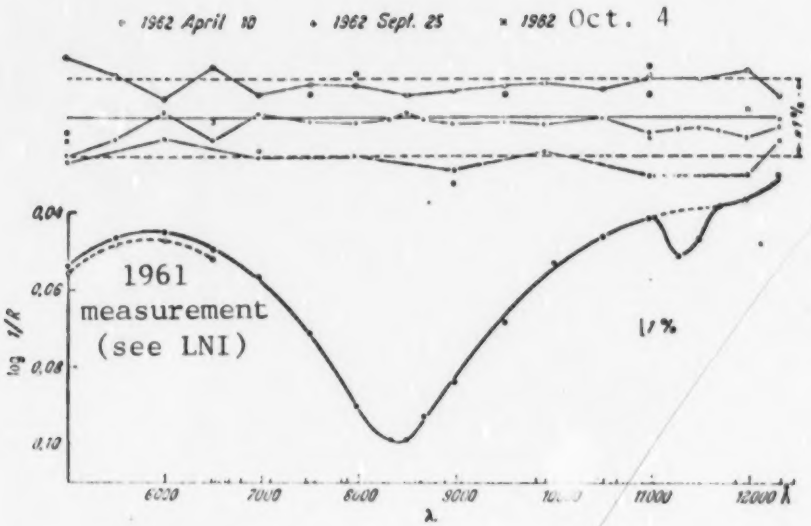

Figure 1. Reflectivity of the collimator mirror.

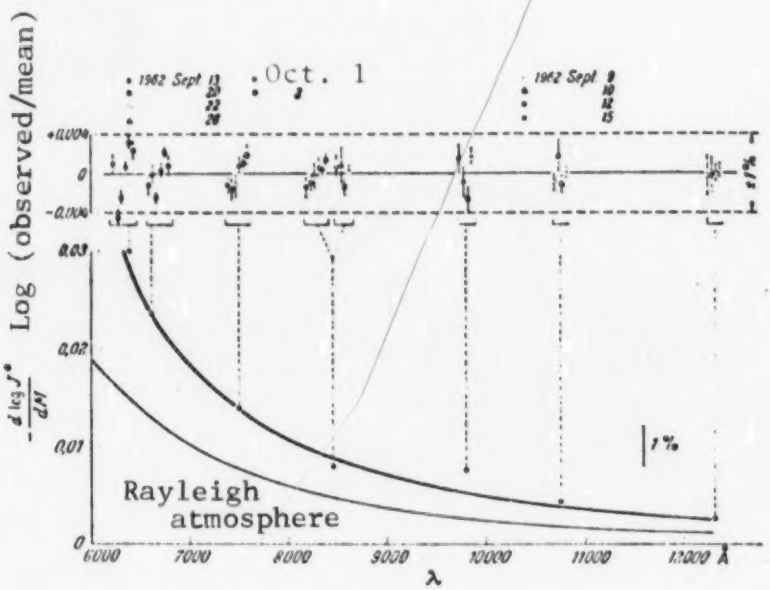

Figure 2. Atmospheric extinction coefficient.

measurement points are marked on the abscissa. The region around $\lambda = 11300$ Å, in which the reflection curve shows a strong dip, is not required for our solar measurements. (3)

Figure 2 shows the atmospheric extinction per unit of air mass. In the upper part of the figure, again, the percentage deviations from the mean, with their mean errors, are marked (4). Each "measuring day", of course, was reduced with "its" extinction coefficients.

Figure 3, finally, shows the measured radiant intensities in bandwidths 20 Å wide. As these measurements include all the Fraunhofer lines in the range, we have reduced them to the continuum intensity by application of the line equivalent widths (see LNI, page 287). In the infrared, this method should be essentially correct and give the true solar continuum.

For comparison, the intensities according to G. F. W. Mulders (1935, 1939), R. Peyturax (1952) and A. Keith Pierce (1953) (the latter conformed absolutely to our value at $\lambda = 9937$ Å) are also plotted in Figure 3. (All data are referred to $\Delta\lambda = 20$ Å).

In order to provide an impression of the accuracy which we attained, we have again in Figure 3 plotted the percentage deviations of theindividual daily results from the mean for the "extinction region". The mean errors of the daily results are also shown, as obtained after a linear compensation of the measured extinction series for the extraterrestrial value. All "days" were given the same weight in the averaging.

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(3) Therefore we need not decide whether this dip is due to the reduced reflectivity of the collimator mirror or perhaps to atmospheric absorption along the path of measurement.

(4) Here the individual measurements have the same weight in the averaging. We indicate the mean error of the slope of the extinction lines, as it appears from compensation of the extinction measurements. Of course, the deviations here are not pure "scattering" about a mean. The extinction will have quite different values on different days.

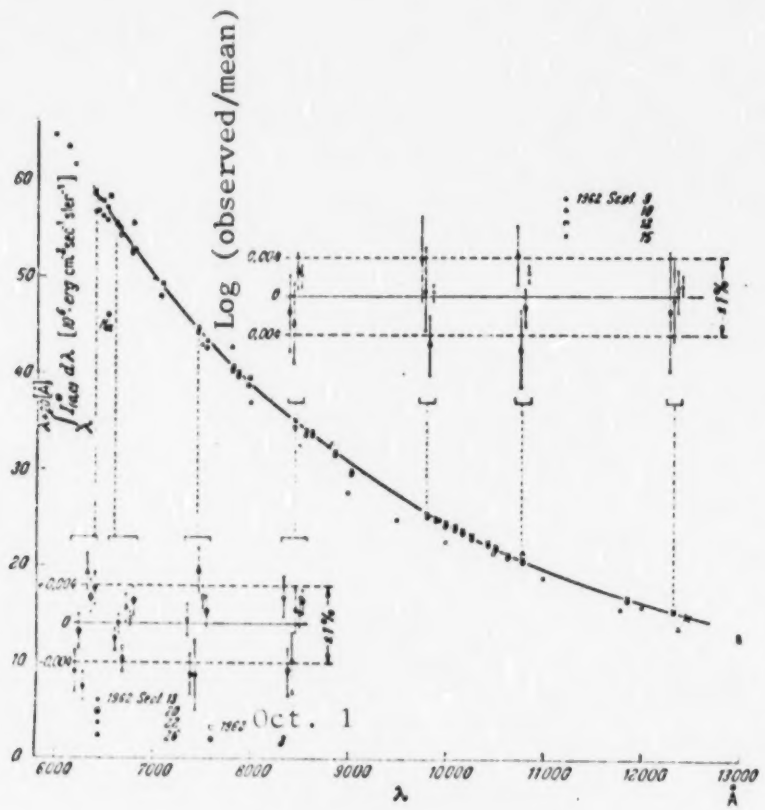

Figure 3. Absolute radiant intensity per 20 Å for the center of the solar disc. • = $\Sigma_{\lambda} = \Sigma_{cont}$ (see table), ○ = Mulders (1935, 1939), △ = Peyturaux (1952), □ = Pierce (1954).

The upper limit of the total error of our measurement (see LNI, page 285) is certainly not underestimated at ± 2.5%.

The table gives our results in numerical form. It contains the short-wave limits, λ[Å] of the 20.0 Å wide spectral regions, the intensity, Σ , integrated over this range, and the continuum intensity, Σ_{cont} per 20 Å bandwidth for the center of the solar disc. (5) The "extinction regions" are marked with a *.

(5) $\Sigma_{cont} = \Sigma(20/(20 - W))$, where W is the sum of the equivalent widths of all the Fraunhofer lines in the particular range.

TABLE

$$\Sigma = \int_{\lambda}^{\lambda + 20.0\,\text{Å}} I_{\odot}(0,0)\,d\lambda \quad [10^{8} \cdot \text{erg} \cdot \text{cm}^{-2} \cdot \text{sec}^{-1}\,\text{ster}^{-1}],$$

$$\Sigma_{\text{cont}} = \int_{\lambda}^{\lambda + 20.0\,\text{Å}} I_{\odot,\,\text{continuum}}(0,0)\,d\lambda$$

λ	Σ	Σ_{conc}	λ	Σ	Σ_{cont}
• 6389	56.5	58.5	8623	33.6	33.8
429	57.0	58.0	870	31.8	32.0
469	56.5	58.0	9032	29.6	29.8
509	56.0	57.5	• 805	25.4	25.6
549	46.0	58.5	894	25.0	25.2
• 611	55.5	55.5	10000	24.4	24.6
653	54.5	55.0	090	24.0	24.2
780	51.5	52.0	169	23.8	24.0
7080	48.0	49.0	260	23.2	23.4
• 455	44.0	44.5	430	22.6	22.6
542	42.5	43.5	500	22.0	22.0
805	40.5	41.0	630	21.2	21.2
865	39.8	40.0	• 758	20.8	20.8
970	39.0	39.6	11 850	16.7	16.9
• 8455	34.6	35.2	• 12320	15.7	15.7
560	33.8	34.0	460	15.1	15.1

It should be noted that the calibration of the comparison light source used for the connection (tungsten ribbon lamp, see LNI) was based on a melting temperature for gold of T_{AU} = 1336.2 [°K] and the radiation constants $C_2 = 1.438_0$ [cm · Grad] and $C_1 = 11.907 \cdot 10^{10}$ [erg μ^4 cm^{-2} sec^{-1} ster^{-1}].

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